# EXHIBIT 20

# A Dictionary of
# Computing

## SIXTH EDITION

OXFORD
UNIVERSITY PRESS

# OXFORD
UNIVERSITY PRESS

3

ister machines, the **while** programming language, and flow charts. The proposition is a scientific hypothesis, subject to empirical and theoretical confirmation rather than mathematical proof. The evidence that it is true is roughly the following.

First, a large number of disparate methods (e.g. those listed above) for computing functions have been shown to be equivalent in power when computing on the natural numbers. Second, there has been a failure to find a function and a convincing method of computing it that has not been computable by one of the known models of computation. Third, philosophically distinct notions – mechanical computability, digital and analog computability, definability in a formal calculus, definability in an algorithmic language – have been investigated and interrelated. Fourth, a generalization of the theory of computable functions to an *abstract computability theory for *algebras has revealed new connections and distinctions between models, but confirmed the primary nature of the features of the computation theory on the natural numbers.

The Church–Turing thesis leads to a mathematical theory of digital computation that classifies what data can be represented, what processes simulated, and what functions computed (*see* COMPUTABLE ALGEBRA). It provides a scientific foundation for a discussion of the scope and limits of computable processes in the physical and biological sciences, and hence attracts the attention of philosophers, scientists, and engineers.

**CICS** *Acronym for* customer information control system. A *transaction processing system widely used on IBM mainframes.

**CIE** *Abbrev. for* Commission Internationale de l'Éclairage. The body responsible for making recommendations with regard to photometry and *colorimetry.

**CIE color model** A *color model developed by the *CIE and based on a standard observer whose color vision is representative of the human population having normal color vision. The first CIE color model was published in 1931. A color is specified by a triad of numbers $(X, Y, Z)$. These *tristimulus values give the amount of each of three hypothetical supersaturated primaries in the color. The $Y$ value gives the *luminance of the object and the primaries are chosen such that the perceptible colors are defined by positive values.

In 1964, the model was updated and based on data with a wider viewing angle and correcting the $Y$ primary, which was found to be slightly in error. Two new specifications, **CIELAB** and **CIELUV**, were defined in 1976. The CIELAB model represents colors on subtractive media, where light is absorbed by inks, dyes, and other pigments; the CIELUV model represents colors on additive color media such as emissive phosphor displays and colored lights. The lightness scale for both is the same and is based on the cube root of luminance, which gives a linear scale.

**CIELAB, CIELUV** *See* CIE COLOR MODEL.

**CIM** **1.** *Abbrev. for* computer-integrated manufacturing. **2.** *Abbrev. for* computer input (on) microfilm, i.e. the process, or the input itself; it is not widely used. Input devices that have been produced have relied on optical character recognition (*OCR) to recode alphanumeric data on microfilm or have read special microfilm on which the data was recorded as binary code. *See also* COM.

**Cineon format** An image file format for storing 35 mm motion-picture images at a resolution of 4096 by 3112 with 10 bits for each color per pixel. The Walt Disney film "Snow White and the Seven Dwarfs" was digitized and enhanced frame by frame using this process.

**cipher** **1.** An *algorithm employed for *encryption, or, in its *inverse form, for *decryption. *See* CRYPTOGRAPHY. **2.** An encrypted message.

**ciphertext** The result of enciphering plaintext. *See* CRYPTOGRAPHY.

**CIR** *Abbrev. for* current instruction register.

**circuit** **1.** The combination of a number of electrical devices and conductors that, when interconnected to form a conducting path, fulfill some desired function. *See also* LOGIC CIRCUIT, INTEGRATED CIRCUIT, PRINTED CIRCUIT. **2.** A physical (electrical) connection used for communication. *See also* CIRCUIT SWITCHING, VIRTUAL CIRCUIT. **3.** of a graph. *Another name for* cycle.

**circuit board** A single rigid board of insulating material on which an electric circuit has been built. It often has an *edge connec-

subset *X* of *S*, *f* maps the least upper bound of *X* to the least upper bound of the *image of *X* under *f*. Continuous functions are significant in *denotational semantics since they correspond to the requirement that a computational process produces arbitrarily close approximations to the final output, given arbitrarily close approximations to the total input.

   A continuous function *f(x)* has no breaks or instantaneous changes in value. In the hierarchy of mathematical functions the smoothest are those, such as sin *x*, cos *x*, that can be differentiated any number of times, always producing a continuous function.

**continuous inkjet printer**   *See* INKJET PRINTER.

**continuous signal, system**   *See* DISCRETE AND CONTINUOUS SYSTEMS.

**continuous simulation**   *See* SIMULATION.

**continuous stationery**   *See* STATIONERY.

**continuous-tone image**   An image, such as a photograph, where the gray levels in the image are continuous and not discrete.

**contradiction**   *See* TAUTOLOGY.

**contrapositive**   of a conditional, $P \rightarrow Q$. The statement

$$\neg Q \rightarrow \neg P$$

where ¬ denotes negation. The contrapositive of a conditional is therefore equivalent to the original conditional. *See also* CONVERSE, INVERSE.

**control bus**   A *bus that is dedicated to the passing of control signals.

**control character**   A character that when typed at a keyboard or sent to a peripheral device is treated as a signal to control operating functions. *See also* CHARACTER SET, ASCII.

**control circuitry**   Electric circuits within a computer or peripheral that regulate its operation.

**Control Data Corporation**   *See* CDC.

**control design**   The design of a *control unit. Control units may be designed using *random logic or *microprogramming. Microprogramming was well suited to the control of the complex sequences of register transfers required by CISC instruction sets.

RISC processors with their emphasis on the rapid execution of simple instruction sets usually employ random logic control to optimize performance.

**control flow**   The sequence of execution of statements in a program.

**control-flow graph**   A *directed graph representing the sequence of execution in a program unit, in which nodes represent branching points or subprogram calls in a program, and arcs represent linear sequences of code. From the control-flow graph an analysis can show

   the structure of the program,
   starts and ends of program segments,
   unreachable code and dynamic halts,
   branches from within loops,
   entry and exit points for loops,
   paths through the program.

*See also* STATIC ANALYSIS.

**control key**   *See* KEYBOARD, CONTROL CHARACTER.

**controlled sharing**   Making used resources available to more than one using resource through an *access control mechanism.

**controller**   A subsystem that governs the functions of attached devices but generally does not change the meaning of the data that may pass through it. The attached devices are usually peripherals or communication channels. One of the functions of the controller may involve processing the data stream in order to format it for transmission or recording.

**control line**   A conductor in a multiwire interface that conveys a control signal.

**control memory**   *Another name for* microprogram store.

**control points**   Points used in the specification of curves to define the general required shape.

**control record**   A record that contains control totals derived by summing values from other records in a file. The totals may or may not have some sensible meaning. Their purpose is to check that none of the preceding records has been lost or altered in some way. *See also* HASH TOTAL.

**control sequence**   A string of characters used to control the operation of a peripheral

defined outside the function, except for the variables passed as parameters.

**refinement** The process in programming whereby higher-level or abstract ideas are progressively reexpressed in terms of lower-level or concrete ones. This can involve both the implementation of procedures in terms of lower-level procedures, and also the representation of abstract data in terms of more concrete data. Both kinds of refinement can involve *specifications, with each step of refinement being shown to preserve the specified behavior of the procedure or data type being refined. Although both terms are rather fluid in meaning, there is a possible distinction to be made between refinement and *program transformation, with the latter involving the replacement of one program fragment by an equivalent one at the same level of abstraction rather than its representation in terms of a lower level of abstraction.

Refinement and transformation are two of the main ideas in the increasingly important study of the systematic derivation of correct programs from specifications.

**reflectance function** A function that defines the spatial distribution and the wavelength composition of the light reflected from an object's surface.

**reflectance model** A mathematical model of how light is reflected from a surface based on a *reflectance function. The basic reflectance model assumes that all surfaces are perfect mirrors. More realistic models use reflectance functions that more accurately represent the properties of real surfaces (see also SPECULAR REFLECTION, COOK–TORRANCE MODEL).

**reflexive closure** See TRANSITIVE CLOSURE.

**reflexive relation** A *relation $R$ defined on a set $S$ and having the property that

$x \, R \, x$

for all elements $x$ in $S$

The relation "is the same age as" defined on the set of people is reflexive. *Compare* IR-REFLEXIVE RELATION.

**refresh (regenerate) 1.** To replenish the charge on the storage capacitors used in *dynamic memory cells and other similar devices. Some devices are provided with internal circuitry that automatically refreshes dynamic cells whenever these cells are read. The word refresh is also used as a noun. **2.** To repeat at regular intervals the display of digital information on a *cathode-ray tube or television monitor in order that the display can appear persistent. *See also* REFRESH FREQUENCY.

**refresh frequency** The frequency with which a display on a cathode-ray tube is regenerated. To avoid *flicker this must be made as high as possible. *See* CFF.

**refutation** A method of reasoning used in logic to refute statements, i.e. to prove them false.

**regenerate** *Another term for* refresh.

**register** A group of (usually) *bistable devices that are used to store information within a computer system for high-speed access. A register of $n$ bistables can store a word of length $n$ bits, which can represent any $n$ bits of information. Different interpretations can be given to the bit configuration stored in the register; for example, the configuration could represent an instruction, a binary number, an alphanumeric character, etc. A register is often the same size as the computer word; it may also be byte- or character-size or some other size as required. Some registers can behave as *counters as well, or they may behave as *shift registers. *See also* MEMORY HIERARCHY.

**register insertion ring** *See* RING NETWORK.

**register optimization** *See* OPTIMIZATION.

**register transfer language (RTL)** Any of several programming languages that allow the declaration of *register configurations within a structure to perform a computation. The timing of transfers between registers, to describe the behavior, is specified by the order in which such transfers are interpreted during the execution of the program. *See also* CHDL.

**regression analysis** A statistical technique that is concerned with fitting relationships between a dependent variable, $y$, and one or more independent variables, $x_1, x_2, \ldots$, usually by the method of *least squares.

A **linear regression model** is one in which the theoretical mean value, $\mu_b$, of the obser-

necting peripheral devices, such as disk storage units, to small and medium-sized computers. Up to seven disk units and one computer can be connected to each SCSI.

**SDH** *Abbrev. for* synchronous digital hierarchy. A set of CCITT standards, and products that implement those standards, intended to support high-speed wide area networking; the intention is to support bit rates from the 100 Mbps range upward. The basic unit within the SDH is the **synchronous transport module**, which at present is defined up to STM-1024.

A major problem for large-scale WANs is that of allowing relatively low-speed links (**tributaries**) to insert data into the high-speed bearer, or recover data from it, caused by timing problems relating to the large difference in clock rates between the tributary and the high-speed bearer – typically 100–1000 orders of magnitude. STM-1 uses a fixed-size module conceptually made up of 9 rows each of 270 bytes. Modules are transmitted at 125 microsecond intervals, row by row and byte by byte, to give a total transmission rate of 155 Mbps. Within each module, specific rows are assigned to specific types of traffic. The first 9 bytes of each row are assigned for timing and control for the contents of the other 261 bytes. The system is designed to allow tributaries to insert or extract data through a series of units, each of which can accept (or deliver) self-timing data at relatively low clock rates, up to about 8 Mbps, or can accept the output from (or deliver input to) such units at speeds that are submultiples of that for the STM-1 system. The "hierarchy" defines the operations and protocols for all the units needed.

**SDK** *Abbrev. for* Software Development Kit. A collection of the software tools, code libraries, documentation, etc., necessary to develop a specific type of software, commonly provided as a single installable package. SDKs may target software development using a specific programming language or *framework, software that runs on a specific *platform, or software that makes use of a specific hardware device or software component.

**SDL** *Abbrev. for* specification and description language. A language used in telecommunications and real-time and interactive systems.

**SDLC** *Abbrev. for* synchronous data link control. A data link control *protocol originally developed by IBM, based on the use of *frames to delimit message boundaries, providing only link-layer functions. Frames consist of an 8-bit frame delimiter (or "flag"), an 8-bit address, an 8-bit control field, a variable-length user information field, a 16-bit frame check sequence, and a final 8-bit frame delimiter. The flag consists of the special character

01111110

and is the only occasion on which six successive ones appear. *Bit stuffing is used to ensure that where the user's information contains five contiguous '1's, the system inserts an additional '0', which is removed at the receiver.

The end-stations are designated as either a primary or a secondary station. There is only one primary station, which initiates and terminates link activity and is responsible for error recovery and for link sharing among multiple secondary stations. The address field has two special values: 0, which is reserved for testing, and 255, which indicates that this is a broadcast frame. The control field is used to carry acknowledgments that frames have been received correctly, or that an error has occurred and that a designated frame is to be retransmitted.

**SDPM** *Abbrev. for* software development process model.

**SDRAM** *Abbrev. for* synchronous dynamic RAM. A type of DRAM (*see* RAM) the timing of whose functions is controlled by the system clock. This makes possible such speed-enhancing techniques as *pipeline processing that rely on coordinated timings between RAM and other components. It is currently (2008) the predominant type of RAM used in microcomputers.

**SEAC** *Acronym for* Standards Eastern Automatic Computer. The first stored-program electronic digital computer to become operational in the USA, in 1950. (*Compare* MANCHESTER MARK I, EDSAC, EDVAC.) It was one of two different pioneer machines developed by the National Bureau of Standards: SEAC was installed in Washington, and the other, called SWAC (Standards Western Automatic Computer), in Los Angeles. Like EDSAC and EDVAC, SEAC used mercury *delay line memory.